A STUDY OF THE REQUIREMENTS GOVERNING THE PERFORMANCE OF THE GARDEN TRACTOR IN VIRGINIA

BY

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PREFACE

This report on "A Study of the Requirements Governing the Performance of the Garden Tractor in Virginia" has been performed and written as a thesis for a Master of Science Degree in Agricultural Engineering from Virginia Polytechnic Institute.

The author wishes to express his thanks to the Agricultural Engineering Department for the use of the quipment and all supplies that were necessary in working out this problem. Also, he wishes to express his thanks to Mr. R. F. Johnson of Union Level, Virginia, who so kindly permitted the use of his tractor and equipment to perform part of these experimental tests. Especially, he acknowledges the invaluable advice and kind personal attention rendered by Professors J. W. Sjogren and P. B. Potter of the department.

S.B.L.

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A STUDY OF THE REQUIREMENTS GOVERNING THE PERFORMANCE OF THE GARDEN TRACTOR IN VIRGINIA

INTRODUCTION

Garden tractor surveys and studies have been conducted among the owners of garden tractors and experimental work has been done by the agricultural experiment stations in other states, but for several reasons these results are not quite representative for conditions in Virginia. Soil types and kinds of crops grown both vary to a considerable extent within the state. Much of the land devoted to crop growing in the state is rolling or hilly, and the use of a garden tractor, therefore, is more difficult. The soil types range all the way from a fine sandy loam to gravelly and stony soils and heavy clays.

All types of vegetables, garden, truck, and other crops are grown in the state. Also nurserymen, poultrymen, florist, and small fruit growers use these small tractors. This wide range of cultivated vegetation in Virginia brings forth quite a number of uses to which the garden tractor can be fitted.

Due to these varying conditions there has been considerable dissatisfaction with the garden tractor in all parts of the state. Some of the factors that cause dissatisfaction are: (1) Buying a tractor that is not large enough to do the work that has to be

done, (2) Buying a tractor that is not well-known in your section of the state, therefore making service and repairs hard to obtain promptly. Queries from unsatisfied users of this type of tractors require that information be secured on them in order that these questions may be answered.

For these reasons it was thought that a study of the requirements governing the performance of the garden tractor in Virginia might reveal some of the advantages and limitations of the various machines, as well as their adaptation to the different types of soils and methods of gardening. Emphasis will be placed on type of tractor, type of traction, types of equipment with reference to pull and ease of attachment, and economy of operation.

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REVIEW OF LITERATURE

This review of literature is a brief story of the size, makes, and purpose of small tractors, as gathered from all available publications on the subject.

The origin of the garden tractor in the United States seems quite recent when compared to its larger more powerful relative, the farm tractor. Six concerns were regularly manufacturing farm tractors in 1904, but the first garden tractor did not appear on the market until about 1916. In some areas garden tractors are still comparatively new.

This small tractor was developed to fill a need in agriculture, particularly in market gardening, small fruit and flower growing, home gardening on a large scale, and in caring for large lawns. This machine has already proven its usefulness and is gaining rapidly in popularity in different sections of the country. As is usual with any machine, it has made enemies as well as friends. As a rule the reason for a dissatisfied customer is a mistake either on his part when buying a tractor or on the part of an over-ambitious salesman.

Farm and garden tractors have passed through corresponding stages of development. At the outset designers of garden tractors attempted a general purpose machine--one that could be used for light plowing and cultivating as well as numerous other jobs and also afford a source of belt power. Many problems occurred, similar to those in the development of the large tractor. The

chief difficulties lay in producing a machine with proper power for good plowing and yet small enough for close cultivation of narrow row-crops. Among other difficulties has been the problem of handling the tractor on all types of land especially on heavy land and hillsides. In fact, as a younger brother to the farm tractor, it has not yet completed its stages of experimentation. Yet we find that it is in real demand. The use of horses is gradually decreasing, especially on small areas where the horse is needed only a few days a year but must eat and be cared for 365 days. Thus the garden tractor is gradually taking the place of the horse. The number of manufacturers furnishes plenty of variety in styles and prices.

There is no sharp line of distinction between farm and garden tractors. Each class contains many sizes and types. For the purpose of this study, however, the garden tractor will include machines with sufficient power to operate one 12-inch moldboard plow or less, and will weigh 200 to 1700 lbs. and cost the purchaser from $100.00 to $600.00. The term "Farm Tractor" will refer to machines with power to operate one 14-inch moldboard plow or more. The lighter model garden tractors have engines of as little as one-half horsepower, while in the larger models the engines may be as large as 10 horsepower.

The term "garden tractor" (although a well chosen expression) has come to be widely used. This class of tractors includes three sizes or types, although the limits of each are difficult to define.

Fig. 1 Large garden tractor (sometimes referred to as auxillary farm tractor.)

The following classification may, however, be of value to anyone interested in this subject.

I. Large Garden Tractors. (Fig. 1)

The capacity of machines of this class is indicated by the following approximate specifications and ratings, which are the result of observation of their use under local conditions.

1. Five to 10 horse power motors (usually 2 cylinders).
2. Riding models.
3. Four wheel types.
4. Pull one 10 or 12-inch plow--to a depth of 7 inches and at the rate of about 2 acres per day under favorable conditions.
5. Operate three 30-inch lawn mowers.
6. Operate five foot field mower,
7. Operate two five foot section harrows.
8. Operate five foot single disc harrow.

II. General Purpose Garden Tractors. (Fig. 2)

1. Three to five horse power motor, usually single or two cylinder.
2. Walking models.
3. Usually two wheel type.
4. Pull eight-inch plow--at rate of one acre per day (Approximate).
5. Operate three and one-half foot field mower--will cut at rate of 3 to 4 acres per day.
6. Operate thirty to 36-inch lawn mower.

Fig. 2 Medium or General Purpose Garden Tractor.

III. Small garden tractors. (Fig. 3)

1. One-half to three horse power motors--usually single cylinder.
2. Walking models.
3. One or two wheel types.
4. Four to six-inch plow (used mostly for hilling and light cultivation).
5. Twenty-two-inch to 30-inch lawn mower.
6. One section (3 ft.) spike tooth harrow.
7. Will cultivate 12-inch rows.

Fig. 3 Small garden tractor (one wheel type).

It has been clearly demonstrated that to get a real general-purpose farm tractor, the integral design of the tractor and its implements is necessary. Special tractor implements were not adequate for use with farm tractors. We are now coming to see the analogy in garden tractors and their equipment. Special tools and implements, hitches, steering or guiding controls, depth adjusting levers, and tool carriages are necessary. In other words, integral design of the power unit and implements is just as vital here as it is on farm tractors. Simply gearing an engine to a pair of light cast iron wheels and bolting on a few wheel hoe tools does not answer the purpose of a garden tractor properly made for the best results.

OBJECTIVES

Considering the reasons and facts given, the objectives of this study are:

1. To conduct a survey among garden tractor users in Virginia, in order to obtain their opinion of the small type tractor.
2. To perform field tests to study the ease of handling and differences in operation of small tractors with one and with two drive wheels under various field conditions.
3. To conduct tests to compare the slippage of drive wheels equipped with rubber tires with those equipped with steel lugs, together with comparison of the fuel consumption.

PROCEDURE

A complete bibliographical study was made of all available material on small tractors such as research articles and other material.

The information about small tractors given in this report was collected in the following ways:

1. Through questionnaires.

Letters were sent to all manufactures of small tractors in the United States, asking them for a complete list of specifications of all their products and also for the name and address of the owners of their machines in Virginia. All companies sent a list of specifications but some companies did not have owners of their products in Virginia. To the list of owners of garden tractors received in this way, others were added that were secured by such means as through the Agricultural Engineering Department at Virginia Polytechnic Institute.

Questionnaires, which included questions on mechanical difficulties, operating difficulties, whether the tractor has been satisfactory for their work, and suggestions for mechanical improvements, were sent to all owners whose names could be obtained. A sample form of this questionnaire may be found in part I of the appendix of this report.

2. Through experimental work.

(a) On the ease of handling.

Tests were conducted in the field with two wheel garden tractors, but only the experience of an owner is given in this report to furnish an idea of the ease of handling the one wheel machine. The two wheel tractor was tested on sloping ground, on different types of soil, and with varying loads and equipment attached. These tests included such things as amount of side creep, ease of turning at end of row, and amount of effort necessary on the part of the operator to cause the machine to properly cultivate crops. Several types of attachments were tried to find the best method to handle tractors on hillsides and also to turn at end of row.

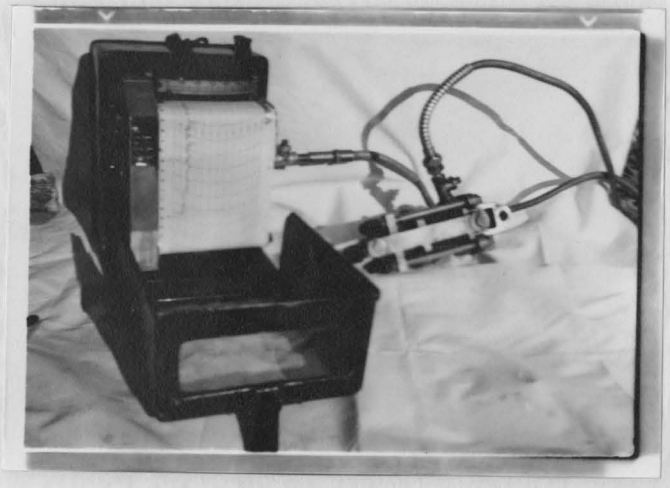


Fig. 4 - Dynamometer Used

(b) On amount of slippage of drive wheels.

Rubber tires and steel lug equipment were tested on the two wheel machines for pulling ability where the following things were taken into consideration: the soil condition,

slope of the land, inflation of rubber tires, weight of the machine, and weight added. Both sets of wheel equipment were tested with the same loads under varying conditions and also tested for maximum load each would pull. The loads in pounds were measured by means of the dynamometer which is shown in Fig. 4. This dynamometer is worked by means of oil pressure which causes a needle to draw a line on a chart showing the pull in pounds. A sample chart is shown in part II of the appendix of this report. Each line on the chart represents a certain number of pounds.

Fig. 5 - Wheel Revolution Counting Device.

The revolutions of the wheels were measured by means of apparatus as shown in Fig. 5. This consists simply of two counters hooked in electric circuits so that everytime a point on the wheels made contact and then broke the circuit, the counters would count one revolution. A hot-shot battery was used to furnish the electrical energy.

The slippage of the wheels was measured by taking the number of revolutions when the tractor was pulling a load and comparing it with the number of revolutions the drive wheels would make in the same distance when there was no load on the machine. The percentage of slippage was figured by dividing the number of revolutions made, when there was no load, into the extra number made when there was a load placed on the machine.

Fig. 6 - Fuel Measuring Device.

Fuel consumption was taken into consideration for all the tests so as to determine which was the most economical set-up of equipment for general purposes. The fuel measuring device is shown in Fig. 6. This is a glass tube, which is calibrated to measure c.c. of fuel used. The c.c. of fuel used was converted to pounds. From the load pulled and the

amount of fuel used by the tractor, the horse power and the horse power hours per gallon of fuel were calculated.

Fig. 7 - Set-up of Equipment With Rubber Tires.
1. Fuel Measuring Device. 2. Revolution Counters.
3. Dynamometer.

Figures 7 and 8 show complete hook-ups of the equipment for test purposes. In Fig. 7, a one-half horse power tractor is shown with rubber tires, while in Fig. 8, a five horse power tractor is shown with steel wheels.

Fig. 8 - Equipment Set-up With Steel Wheels.

All data taken in these field tests for slippage was kept on field test data sheets as shown in part III of the appendix of this report. The charts, tables, and graphs of the results are made up from the data taken from these data sheets.

RESULTS FROM QUESTIONNAIRES

The following information was obtained from the questionnaires sent to owners in the state. Of the 70 questionnaires sent out, 42 answers were received. Ten of the people had either sold their tractor, worn it out, never had one, or for some other reason could not fill out the questionnaire. Thirty-two filled out questionnaires were returned and from these, the following conclusions were drawn.

Table No. I gives a list of operations performed by garden tractors in Virginia as reported by owners. This list is arranged as nearly as possible according to the number of owners reporting each operation, that is, cultivating is the most common operation, plowing next and so on throughout the list.

Table No. I

Operations performed by Garden Tractors in Virginia.

1. Cultivating.
2. Plowing.
3. Harrowing.
4. Leveling.
5. Lawn mowing.
6. Covering rows after planting.
7. Opening rows for planting.
8. Planting and seeding.
9. Digging potatoes.
10. Hauling cart or trailer.

11. Mowing hay.

12. Sawing wood.

13. Grinding feed.

14. Pulverizing soil.

15. Mixing concrete.

16. Pulverizing hot beds.

17. Pulling road drag.

18. Dragging logs.

19. Making lawns.

20. Digging ditches.

21. Digging flower bulbs.

22. Golf course discing.

23. Preparing soils in Greenhouse.

24. Pulling spray pump.

25. Cutting grass among trees in nursery rows.

The answers to the following questions are especially interesting.

1. Do you consider the garden tractor a good investment on your place?

Twenty-six, yes; six, no.

2. Does your tractor have the following attachments?

(a) Reverse gear. (Fourteen, yes; 18, no.)

(b) Power takeoff. (Eleven, yes; 21, no.)

(c) Belt pulley equipment. (Nineteen, yes; 10, no; 3, no report.)

(d) Rubber tires. (Four, yes; twenty-eight, no.)

3. Do the items listed in question No. 2 give satisfactory results?

Twenty, yes; three, no; nine, not reporting.

4. Are the tractor wearing parts sufficiently protected from dirt and dust?

Twenty-three, yes; four, no; five, no report.

5. Can repairs be obtained without much delay?

Twenty-two, yes; five, no; five, no report.

6. Approximately how many days per year do you use your tractor?

Average of those reporting, 65.5 days per year. Twenty-two reporting.

7. How does the quality of work done with your garden tractor compare with that of horse-drawn implements?

Fourteen report better; nine report just as good; five report not as good; three not reporting; one reported it depends upon the conditions.

8. Are the tractor controls easily accessible to the operator?

Thirty, yes; two, no.

9. Is it desirable to have width of tread adjustable for different widths of rows?

twenty-one, yes; four, no; three, no report; four owned one wheel tractors so did not express their opinion.

10. Will tractor turn at ends of row with little manual effort and is it easy to handle on hillsides?

Eleven, yes; nine, no; two, no report; four, easy to turn but never have used on hillsides; six, easy to turn, but hard to handle on hillsides.

11. Do you consider your tractor reliable and dependable?

Twenty-five, yes; three, no; four, no report.

12. Does it meet your requirements fairly well?

Twenty-five, yes; four, no; three, no report.

13. Is your tractor satisfactory for plowing?

Twenty-three, yes; five, no; four, no report.

14. What depth?

Anywhere from 2 to 10 inches; 7 inches is the average.

15. How does garden tractor compare with horse-drawn implements in amount of work done in a day?

Two, more; seven, about the same amount; four, not as much; 21, not reporting.

16. How does the garden tractor compare with the horse-drawn implements in ability to cultivate close to young plants and ridged crops?

Fourteen, better; two, closer on flat land; seven, just as good; three, not as good; six, not reporting.

17. Are the tractor controls easily accessible to the operator?

Twenty-nine, yes; one, not reporting; one reports all are except reverse; and one fairely easily.

18. How many gallons of fuel used per year?

Seventeen reporting; fifteen not reporting. One hundred and thirty gal., average; 270, highest; 4, lowest.

19. How many quarts of oil used per year?

Fourteen, reporting; eighteen, not reporting. Twenty-eight qts., average; 55, highest; 4, lowest.

20. Cost per year for repairs?

Nine, report nothing on machines that have been used on an average of 2½ years; 13, reporting cost--an average of $13.40 on machines that have been used on an average of 3½ years; 10, not reporting.

21. How old is your tractor?

An average of a little over four years on 30 reporting. The oldest, 13 years and newest is one year old.

22. Approximately how many more years of service will tractor give?

Nineteen, report an average of 8 more years; 11, no report; 2, report tractor worn out.

Owners were asked to "List and describe difficulties experienced in operation, faults in construction, weak effective parts, motor troubles, etc." The following items were given as an answer to this question:

1. Clutch should be better. (Reported by 2 owners)
2. Should have two forward speeds. (Reported by 1 owner)
3. Bad differential. (Reported by 2 owners)
4. Magneto went bad. (Reported by 2 owners)
5. Hard to turn around. (Reported by 5 owners)
6. Failure of spark plug. (Reported by 1 owner)
7. Not enough power. (Reported by 1 owner)
8. Not enough weight. (Reported by 1 owner)
9. Chain drive bad. (Reported by 1 owner)
10. Should have reverse. (Reported by 1 owner)

11. Bad piston. (Reported by 1 owner)

12. Bad valves. (Reported by 1 owner)

13. Air cleaner stopped up. (Reported by 1 owner)

14. Weak construction. (Reported by 1 owner)

15. Hard to adjust throttle. (Reported by 1 owner)

The question "In your opinion what changes or improvements in design would make it possible to secure results from your machine?" resulted in the following suggestions:

1. A little more speed in high gear.

2. Easier turning facility.

3. A reverse gear.

4. Better oiling system.

5. Better method of handling cultivating tools.

6. Larger valves and better material in the valve construction.

7. Two forward speeds.

8. Rubber tires.

9. Better protection of wearing parts from dirt and dust.

10. A more substantial motor that you do not have to take apart so often to make adjustments and repairs.

The following remarks were made by owners (for and against their tractors):

1. A small tractor should be very practical for working a few acres of level land.

2. Works fine. Just wish had more acres to work.

3. Tractor is easy to upset when hits a hole or low spot.

4. My tractor has been much more economical for me than a horse.

5. A garden tractor is the handiest thing on the farm. It does not eat when not at work.

6. I have a larger tractor that I do most of the work with. We don't have any horses and so we couldn't do without our garden tractor.

7. Our machine is the largest labor saver we have on the farm.

#######

RESULTS FROM EXPERIMENTAL WORK

I. On ease of handling.

It was found that the following factors have a great effect upon the ease of handling small tractors: (1) the soil type, (2) the slope of the ground, and (3) the type of crop growing. These factors vary considerably in different sections of the state, so where one type of tractor would be easy to handle in one place, it might not be at all easy to handle in another, or some other type might be easier to handle in that section.

The one wheel tractor is easier to handle in close places and on steep hillsides than the two wheel type, but the operator has to carry a part of the weight a great deal of the time and this will naturally make him tired if he has to operate the tractor for a length of time. It is hard to handle the one wheel type on rocky land as the wheel will hit rocks and jump to one side or bounce over top and lose power. This type of garden tractor will do small light cultivation work very well, but it is too hard to handle when trying to pull loads on trailers or doing any kind of heavy work.

Both rubber tires and steel wheels were used in testing the two wheel tractors for ease of handling. Also, various other attachments were tested, as shown in Fig. 9, and some of them were found to help considerably in reducing the hardships of handling the two wheel machines.

It was easier to turn at the end of the row when each wheel had a brake on it as shown by letter B in Fig. 9. Just press

the thumb level of the brake on the side you wanted to turn towards and the tractor would turn on its own power. A complete turn could be made in a space twice the width of the tractor. This saves the operator the trouble of lifting the weight of the tractor and pushing it around.

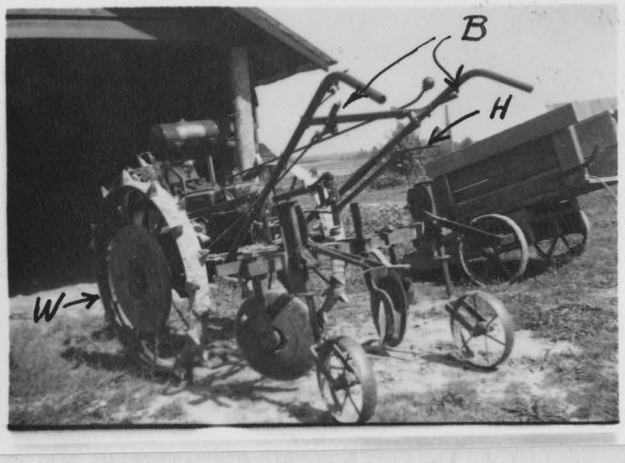


Fig. 9 - Attachments used to make the tractor easier to handle.
W - Wheel Weight. B - Wheel Brakes. H - Hand Lever.

The hand lever as shown by the letter H in Fig. 9 is a great help when close cultivation of small row crops is desired. The operator can move it to the right or left as far as he wants to with a very little effort and this will cause the cultivating attachments to move closer or further from the crop. This saves the operator the trouble of turning the tractor so often and thereby makes it easier to handle when cultivating small crops.

When plowing with one wheel in the furrow or using the tractor on the side of a hill, a wheel weight as shown by the letter W in Fig. 9 will reduce both the side creep of the machine and the slippage of the upper wheel. A closer view of this weight is shown in Fig. 10.

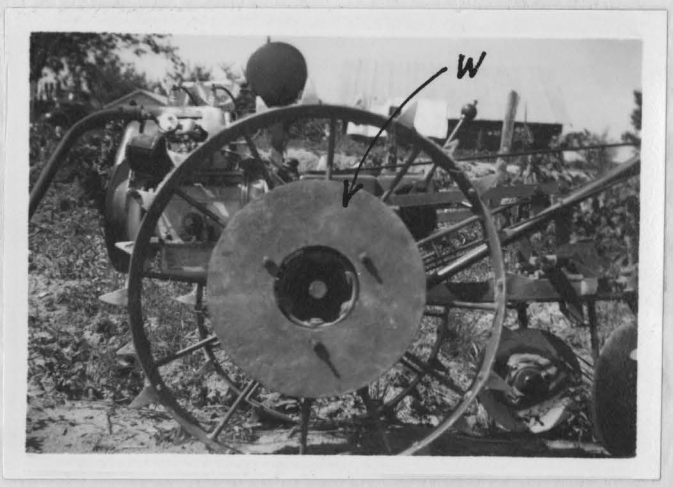


Fig. 10 - Wheel Weight.

The weight weighs sixty pounds and is very easy to attach as it has three clamps that fit over the spokes of the wheel. This weight causes the upper wheel to get more traction thereby reducing spin of the wheel when it hits soft soil or some object like a rock or stick.

The steel wheels were found to be easy to handle on a grass sod or firm soil, but the rubber tires were found to be easier to handle on soft soil or rocky land.

II. Slippage of Drive Wheels.

The results from the experimental test with a small tractor, equiped with both rubber tires and steel wheels, are given in Tables II and III. Table II is a complete record of data taken on plowed ground while Table III includes all data taken on grass sod. The rubber tires were tested with and without 50 lbs. of water added to each tire. The air pressure in the tires was varied from 3 to 15 lbs.

It was found from Chart No. I, on percentage slippage of drive wheels, that the steel wheels had about half the slippage on grass sod as on the plowed ground. There was some difference in the amount of slippage of the rubber tires, when 50 lbs. of water was added and when not added on the grass sod; but not as much difference as on the plowed ground. The slippage was less in all cases when the air pressure of the tires was at three pounds and was greater at the higher air pressures.

Table No. 4 gives the maximum loads pulled and the percent slippage on both grass sod and plowed ground for the different types of wheel equipment.

It is found by Chart No. 2 that rubber tires, without weights added, had more slippage on grass sod than on plowed ground; but that both the steel wheels and the rubber tires, with 50 lbs. of water added to each tire, had less slippage on the grass sod than on the plowed ground. The rubber tires, with 50 lbs. of water

TABLE NO. II GARDEN TRACTOR FIELD TEST DATA (PLOWED GROUND)

NAME OF TRACTOR Beeman MODEL Junior HORSE POWER ½ WEIGHT OF TRACTOR 340 lbs.
DISTANCE TRAVELED 200 FT. PERCENT GRADE Level Ground WEATHER CONDITIONS Hot and dry.

WHEEL EQUIPMENT	RUBBER TIRES NO WEIGHT ADDED DIA. 8 ft.					RUBBER TIRES DIA. 8 ft. 50 lbs. of water added to each.					STEEL WHEELS DIA. 7.85 ft.
AIR PRESSURE IN TIRES (LBS.	3	6	9	12	15	3	6	9	12	15	
Time of run (Sec.)	135	140	140	145	140	150	150	150	150	150	145
Speed (Miles per Hr.)	1.01	.97	.97	.94	.97	.91	.91	.91	.91	.91	.94
Drawbar pull (Lbs.)	130	130	128	125	120	180	180	175	175	175	110
Fuel used in run (c.c.)	19.5	19.7	20	21	20	25.0	25.0	24.0	25.0	26.0	20.5
Fuel Consumption (Gal. Hr.	.134	.130	.132	.133	.132	.156	.156	.148	.156	.162	.130
Horse power developed	.354	.338	.331	.320	.312	.436	.436	.423	.423	.423	.300
H. P. Hrs. per Gal.	2.64	2.60	2.50	2.40	2.36	2.80	2.80	2.84	2.71	2.61	2.30
Rev. of drive wheels loaded	27.0	27.0	27.8	28.5	29.0	26.4	26.7	27.2	27.4	27.8	28
Rev. of drive wheels no load	26.3	26.0	26.0	25.8	25.8	26.2	26.0	26.0	25.8	25.8	26
Percentage of slippage	2.65	3.84	6.92	10.46	12.40	.76	2.70	4.61	6.20	7.75	7.69

Remarks -
Plowed ground was not very hard or very soft. It had been plowed for several months and had rained and packed the ground.

TABLE NO. III GARDEN TRACTOR FIELD TEST DATA (GRASS SOD)

NAME OF TRACTOR Beeman MODEL Junior HORSE POWER ½ WEIGHT OF TRACTOR 340 lbs.
DISTANCE TRAVELED 200 FT. PERCENT GRADE Level Ground WEATHER CONDITIONS Hot and dry.

WHEEL EQUIPMENT	RUBBER TIRES CIR. 8 ft. NO WEIGHT ADDED					RUBBER TIRES CIR. 8 ft. 50 lbs. of water added to each.					STEEL WHEELS CIR. 7.85 ft.
AIR PRESSURE IN TIRES (LBS.)	3	6	9	12	15	3	6	9	12	15	
Time of run (Sec.)	138	138	135	135	135	130	135	140	145	150	138
Speed (Miles per Hr.)	1.00	1.00	1.01	1.01	1.01	1.06	1.01	.97	.94	.91	1.00
Drawbar pull (Lbs.)	150	145	140	125	120	150	150	156	160	160	140
Fuel used in run (c.c.)	18	18.5	17.5	18	17.5	16	16.5	16.8	18.5	19	18
Fuel Consumption (Gal. Hr.)	.121	.124	.120	.121	.120	.112	.115	.114	.120	.119	.121
Horse power developed	.41	.396	.382	.340	.327	.42	.41	.405	.402	.390	.382
H. P. Hrs. per Gal.	3.38	3.20	3.18	2.73	2.70	3.75	3.56	3.55	3.39	3.27	3.16
Rev. of drive wheels loaded.	27.5	27.5	28.0	27.7	27.8	27	27.2	27.5	27.8	28.0	26.5
Rev. of drive wheels no load	26.3	26.0	26.0	25.6	25.6	26.3	26.3	26.3	26	26.0	25.5
Percentage of slippage	4.56	5.77	7.69	8.20	8.59	2.65	3.42	4.56	6.92	7.69	3.92
Remarks -											

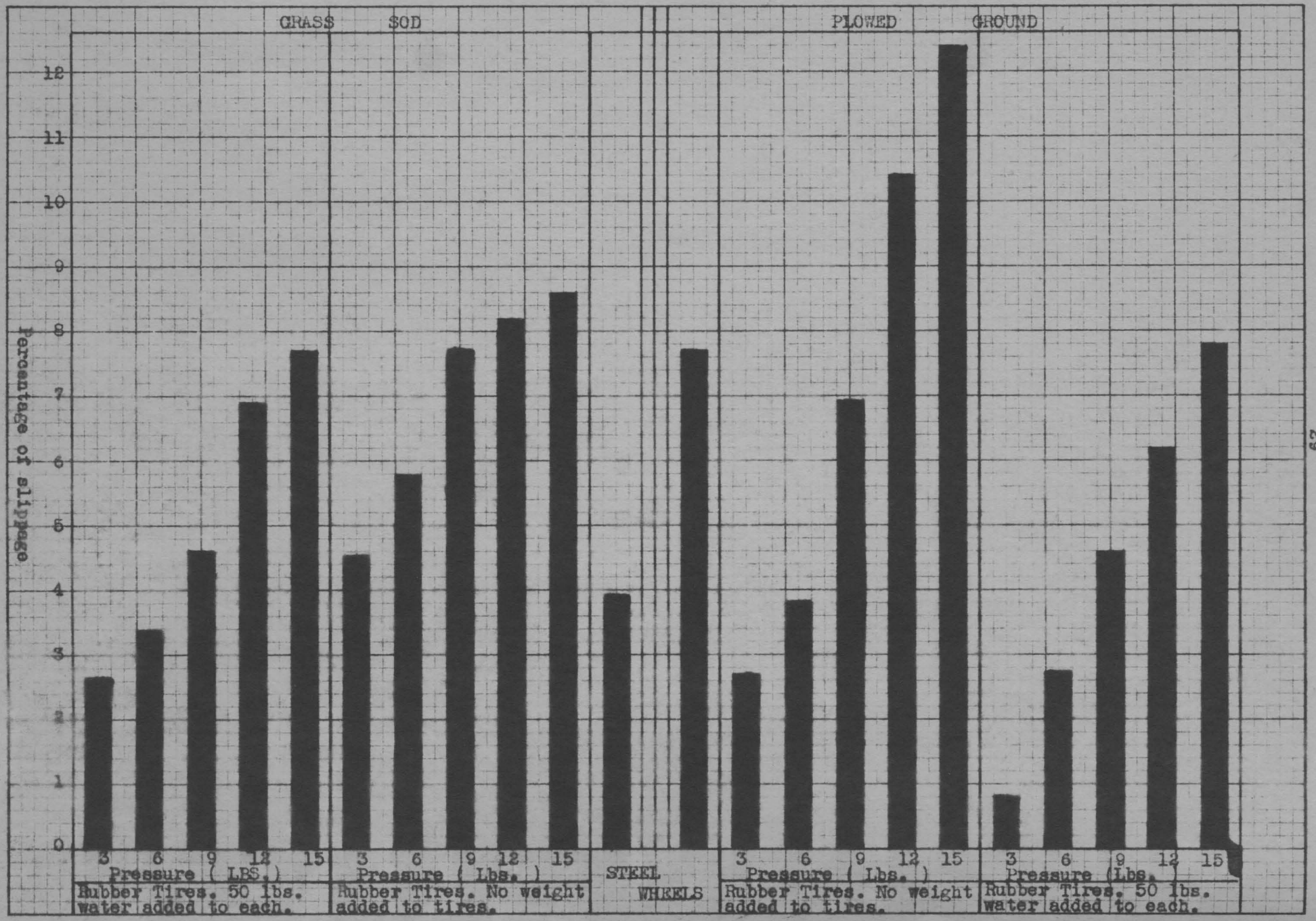
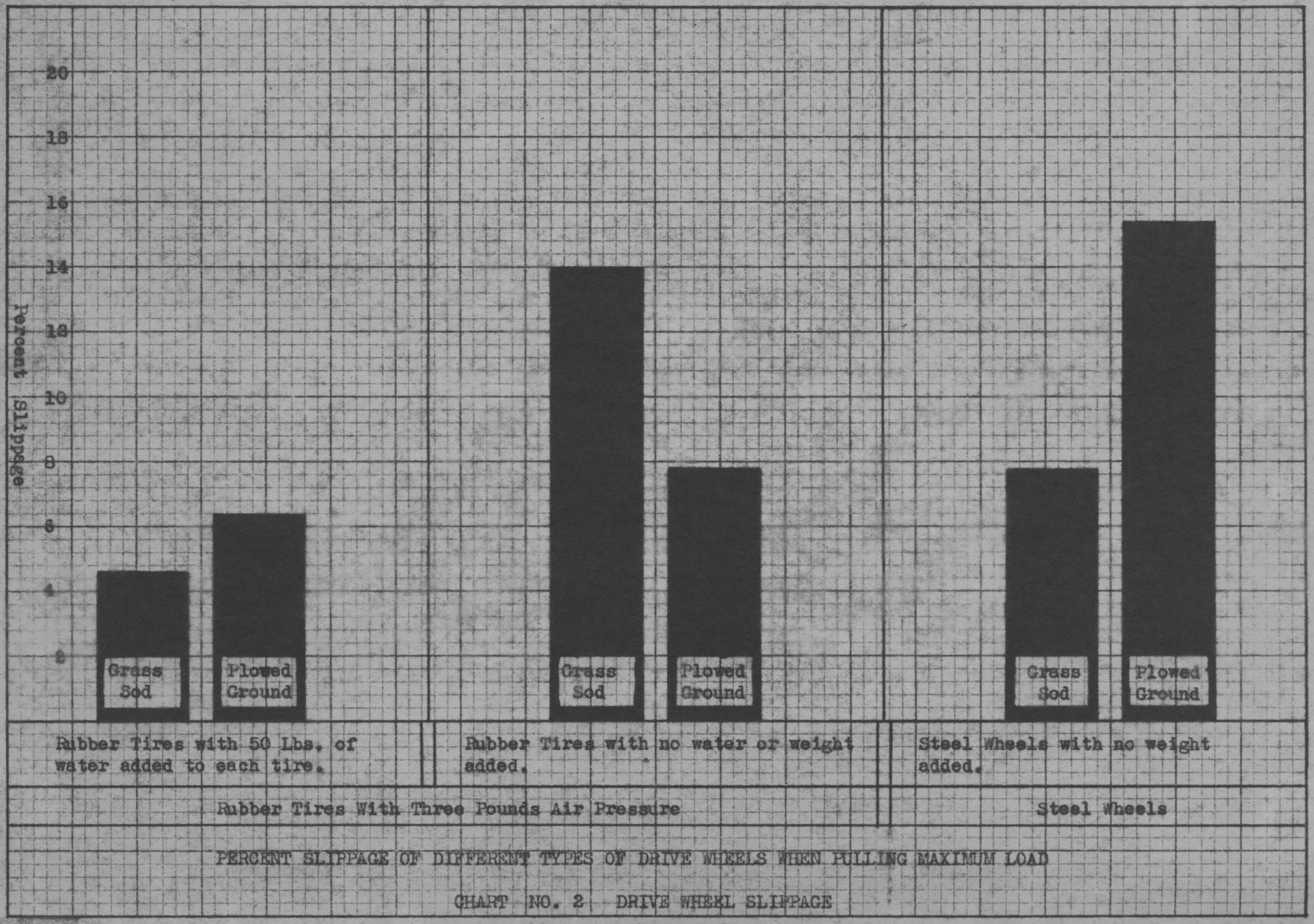


CHART NO. 1 PERCENT SLIPPAGE OF DRIVE WHEELS



PERCENT SLIPPAGE OF DIFFERENT TYPES OF DRIVE WHEELS WHEN PULLING MAXIMUM LOAD

CHART NO. 2 - DRIVE WHEEL SLIPPAGE

added to each tire, had considerably less slippage on both the grass sod and the plowed ground, than either the steel wheels or the tires without water added.

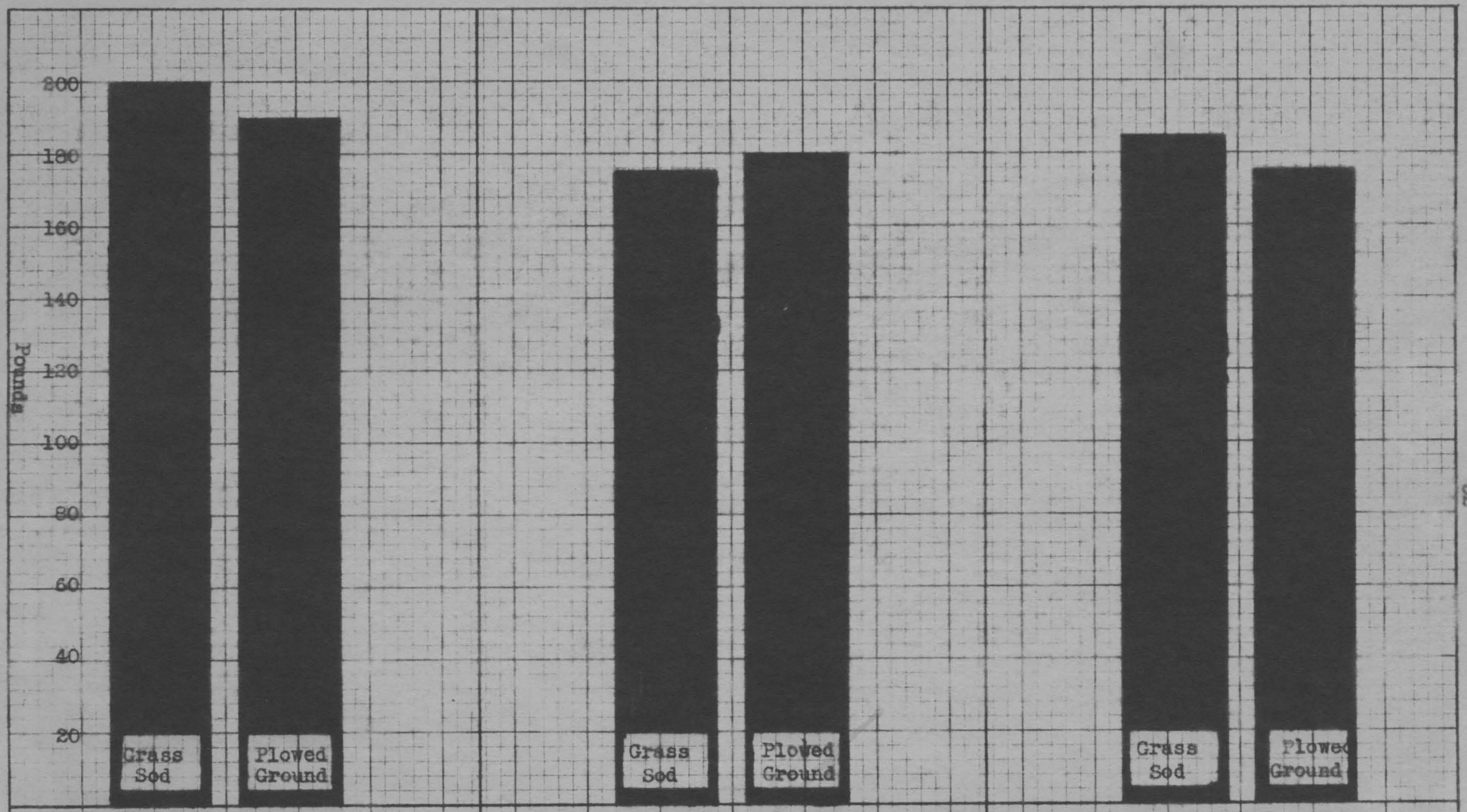
Table No. IV Maximum Loads Pulled By Different Types of Wheel Equipment and Amount of Wheel Slippage for Each Load.

Type Wheel Equipment	Grass Sod		Plowed Ground	
	Maximum Load	Percent Slippage	Maximum Load	Percent Slippage
*Rubber tires and 50 lbs. of water added to each tire.	200	4.51	190	6.46
*Rubber tires and air.	175	14.06	180	7.82
Steel Wheels	185	7.84	175	15.38

*Rubber tires with 3 lbs. air pressure.

Chart No. 3 shows the maximum load in lbs. that the different types of wheel equipment will pull. Here again, the rubber tires, with the water added for weight, gives the best results as a greater load can be pulled with less slippage. The steel wheels give second best results except in plowed ground or soft sandy soil. On soft ground, the rubber tires without weight added, gives a little better result than the steel wheels, but they are not as good on grass sod.

Chart No. 4 shows the horsepower hours per gallon of fuel obtained with the different types of wheel equipment. The maximum was obtained with all the equipment on the grass sod. At three pounds air pressure in the tires, the best results were obtained in all cases except on the plowed ground with rubber



Rubber Tires with 50 lbs. of water added to each tire.

Rubber Tires with no water or weight added.

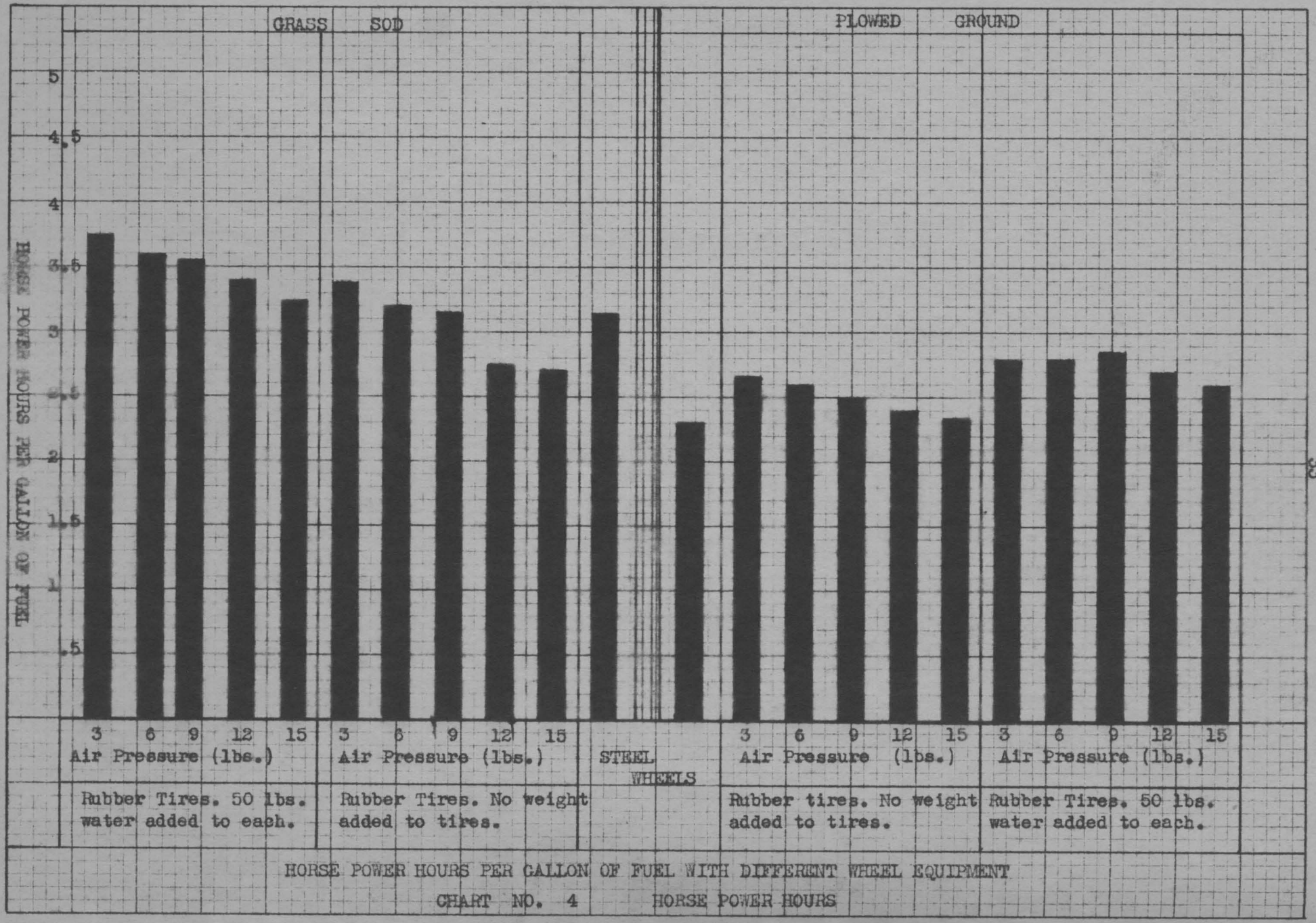
Steel Wheels with no weight added.

Rubber Tires With Three Pounds Air Pressure

Steel Wheels

MAXIMUM LOADS PULLED WITH DIFFERENT TYPES OF DRIVE WHEELS (Plowed Ground & Grass Sod)

CHART NO. 3 MAXIMUM LOADS PULLED



HORSE POWER HOURS PER GALLON OF FUEL WITH DIFFERENT WHEEL EQUIPMENT

CHART NO. 4 HORSE POWER HOURS

tires and water added. Here the best results were obtained at 9 lbs. air pressure.

Table V gives all data taken on test with a five horsepower tractor that had steel wheels and two forward speeds. These tests were performed under different soil conditions. From this table it is found that greater loads can be pulled with low gear, but the slippage of the drive wheels is greater for low than it is for high gear. Also from this table, it is found that the h.p. hrs. per gallon of fuel is greater for high gear speed. Therefore, it is more economical to use high gear if possible when pulling loads.

TABLE NO. V RESULTS FROM TEST, UNDER DIFFERENT SOIL CONDITIONS, WITH A 5 H. P. TRACTOR THAT HAD STEEL WHEELS AND TWO FORWARD SPEEDS.

NAME OF TRACTOR Standard MODEL '37 Twin HORSE POWER 5 WEIGHT OF TRACTOR 512 lbs.
DISTANCE TRAVELED 200 ft. PERCENT GRADE Level ground WEATHER CONDITIONS Hot and Dry.

SOIL CONDITIONS	Gear	Time of Run (Sec)	Speed Miles Per Hour	Drawbar Pull (lbs.)	Fuel Used (c.c.)	Fuel Consumption (Gal/ hr.)	H.P. Developed	H.P. hrs. Per Gal.	Rev. of Drive Wheels Loaded	Rev. of Drive Wheels Not Loaded	Percent Slippage
Plowed & Harrowed Ground. Firm as it had rained twice since plowed.	High	72	1.90	240	25	.325	1.22	3.75	27.0	25.5	5.90
"	Low	95	1.43	250	35	.340	.95	2.80	27.5	25.5	8.62
Rye sod. Soft about 2 inches on top.	High	75	1.81	285	25	.312	1.38	4.42	28.0	26.0	7.70
"	Low	100	1.36	300	40	.370	1.10	3.00	28.5	26.0	9.76
Sandy Roadway.	High	78	1.72	260	30	.366	1.20	3.57	27.5	25.8	6.60
"	Low	120	1.13	325	40	.290	1.00	3.45	28.0	25.8	8.52
Grass Sod.(Firm)	Low	100	1.36	330	36	.331	1.20	3.62	25.8	25.4	1.57

Remarks:

CONCLUSIONS

The making of all decisions is drawn directly from the results of this report. Throughout this report, it is found that no single garden tractor can be made which will perform all operations to the best advantage. This is true with farm tractors and it is also true with garden tractors.

From the questionnaires we find, that although there are a lot of complaints against the garden tractor, that about 77 percent of the present owners are well satisfied with their tractors. The other 23 percent were usually owners that had bought tractors too small for the work that they had to do, and therefore they did not get the service out of the tractor that they had expected. From this, we find that it does not pay to buy a tractor that is too small for the work that has to be done.

For the ease of handling: here again a careful selection should be made of the type of tractor that will best suit the soil conditions, the type of work expected from it, and the slope of the land. The one wheel tractor is easier to handle on light cultivation jobs and in close places, but the two wheel tractors, on the average, are best for all types of work, especially the heavier work. When pulling heavy loads, some means or device should be on the tractor so as to cause it to turn under its own power instead of the operator having to turn the load. A weight on the drive wheel on the upper side of the hill, when working on hillsides will reduce both the side creep of the machine and the spin of the upper wheel. Tractors

equipped with rubber tires were found to be easier to handle in most places than a tractor equipped with steel wheels. There is certainly less wear on the tractor itself when equipped with rubber tires.

Greatest slippage of drive wheels occurs when the tractor is equipped with rubber tires that contain high air pressures and no weights on them, but rubber tires are considerably better than the steel wheels when the air pressure is low. When water is added in the tire and the air pressure is still low, the least amount of slippage is obtained. Air pressures of from 3 to 6 lbs. was found to be the best in the tires as there was less slippage of wheels and the tractor could pull greater loads. Steel wheels cause a lot of slippage in plowed ground, but are nearly as good as the rubber tires filled with water on grass sod. They are better than the rubber tures with high air pressures.

It is more economical, in the use of fuel, to use tractors equipped with rubber tires with low air pressures, and when the tractor has two forward speeds it is cheaper to use the higher speed as much as possible.

SUGGESTIONS TO PROSPECTIVE PURCHASERS

From the conclusions just given before this, a few suggestions will be given here for the guidance of prospective purchasers:

1. Be sure to get authoritative information as to the records of performance of the tractors under conditions similar to the conditions of your locality.

2. If possible, purchase only after seeing the machine demonstrated. Be sure to observe the action of the cultivator control and examine the hitch and tool carriages.

3. Operate the machine yourself before buying and be sure it is large enough to best suit your principal operations.

4. Be sure that repairs and service can be obtained quickly for the tractor you buy.

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APPENDIX

PART I SAMPLE QUESTIONNAIRE

GARDEN TRACTOR INFORMATION FOR RESEARCH WORK AT V.P.I.

Name of garden tractor _____ Model _____

Horse power _____ Weight _____ Purchase price _____

****

1. Does purchase price include any equipment? _____ If so, how much?_____

_____

2. Does your tractor have: (a) Reverse gear? ____ (b) Power takeoff? _____

(c) Belt pulley equipment? _____ (d) Rubber tires? _____.

3. Do the items listed in question number two give satisfactory results? ___

_____

4. How old is your tractor? _____ Approximately how many more years of service will tractor give? _____

5. How many acres do you farm? _____ Do you consider the garden tractor a good investment on your place? _____

6. Are the tractor controls easily accessible to the operator? _____

7. In your opinion how does the garden tractor compare with horse-drawn implements in:

(a) Quality of work _____

(b) Ability to cultivate close to young plants and ridged crops _____

_____

(c) Amount of work done in a day _____

_____

8. Is it desirable to have width of tread adjustable for different widths of rows? _____

9. Will tractor turn at end of row with little manual effort and is it easy to handle on hillsides? _____

_____

APPENDIX
- 2 -

10. Do you consider your tractor reliable and dependable? _____ Does it meet your requirements fairly well? _____

11. Is your tractor satisfactory for plowing? _____ What depth? _____

12. Draw a line under each of the operations that you perform with the tractor: Cultivating, plowing, harrowing, lawn mowing, mowing hay, planting or seeding, opening rows for planting, covering rows after planting, leveling, digging potatoes, spraying, sawing wood, pumping water, grinding feed. List others not mentioned in above list _____

13. Are the tractor wearing parts sufficiently protected from dirt and dust? _____ Can repairs be obtained without much delay? _____

14. Approximately how many days per year do you use your tractor? _____

15. Operation costs per year for garden tractor:

(a) How many gallons of fuel used per year? _____

(b) How many quarts of oil used per year? _____

(c) Cost per year for repairs? _____ Skilled labor? _____

16. List and describe the difficulties experienced in operation, faults in construction, weak effective parts, motor troubles, etc. _____

_____

_____

17. In your opinion what changes and improvements would make it possible to secure better results from your machine? _____

_____

_____

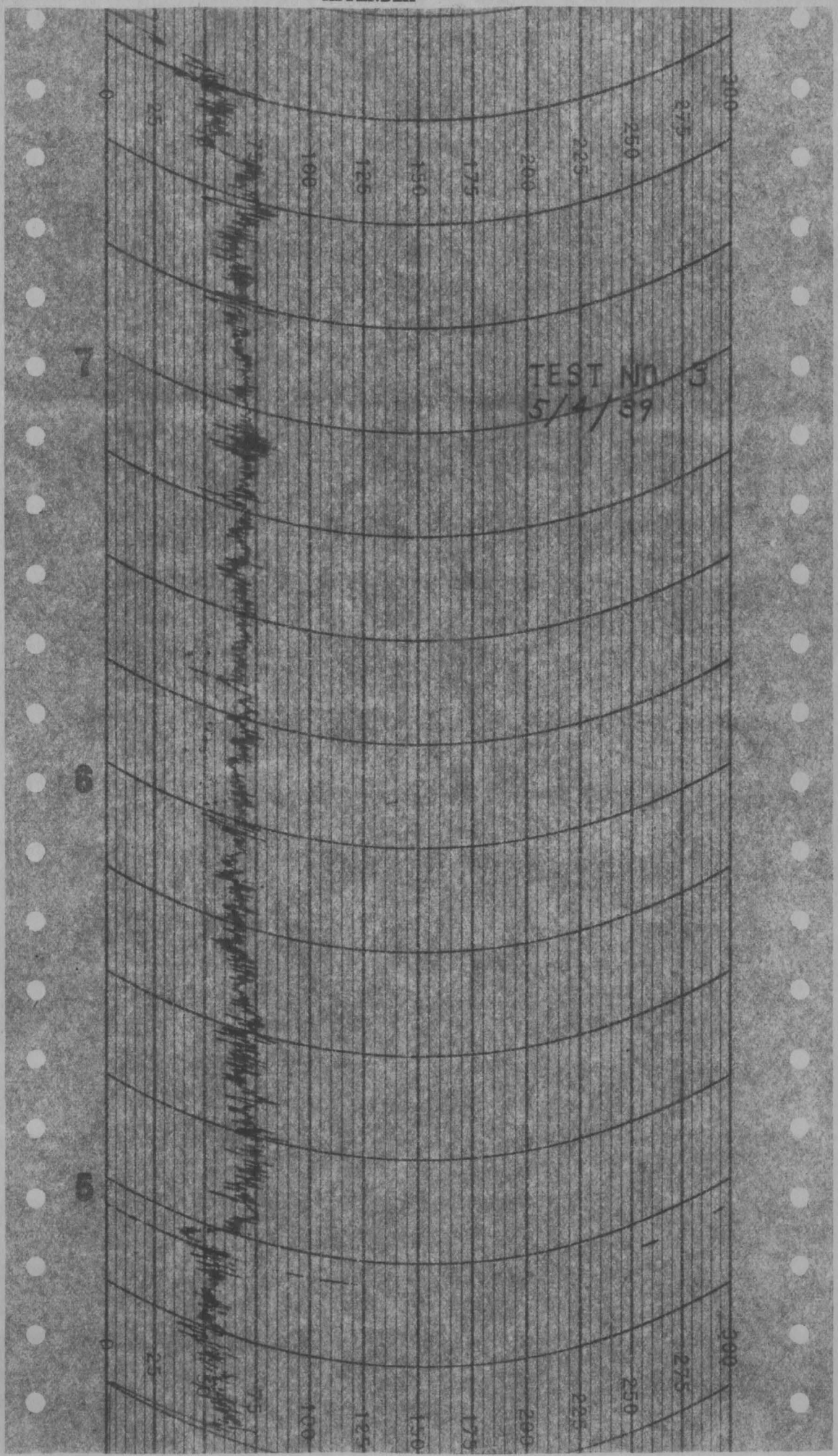
18. Remarks of owners (for and against the tractor) _____

_____

_____

Owner's Name _____

Address _____



PART II SAMPLE DYNAMOMETER CHART

APPENDIX

PART III SAMPLE FIELD TEST DATA SHEET

Garden Tractor Data Sheet for Field Test

Test No. _____ Date _____ Observers _____

Name of Tractor _____ Model _____ Horse Power _____

Weight of Tractor ____lbs. Weather Conditions _____

Soil Conditions _____

Distance Traveled in Test _____ Percent Grade _____

Time of Run. _____min. _____sec. Speed (miles per hr.) _____

Drawbar pull in lbs. _____ Fuel used in run (c.c.) _____

Fuel Consumption in Gal/Hr. _____ H.P. hr./Gal. _____

Type of Wheel Equipment _____ Cir. of Drive Wheels ____

Weight Added (lbs.) _____ How? _____

Revolutions of Drive Wheels: Right _____ Left _____

Revolutions of Drive Wheels if no Slippage Occurred _____

Percentage of Slippage _____

If Rubber Tires, at What Pressure Tested. (lbs.) _____

H.P. _____

_____

Remarks: _____

_____

_____